The Examiner Thanh T. Nguyen is thanked for carefully examining and reviewing the subject Patent Application. With entry of this response to the Office Action, claims 23 - 27 are considered to be in condition for allowance.

In an earlier office action, claims 1 - 22 were canceled by the Applicant, and non-elected claims 28 - 41 were withdrawn and canceled. The previous argument of the Applicants were filed and received on 2/2/04, not on 8/8/03 as stated in the "Response to Arguments".

BACKGROUND AND SUMMARY OF INVENTION

This invention relates to a method of fabrication used in semiconductor integrated circuit devices, and it relates to structures for reducing capacitance between closely spaced interconnection lines of integrated circuits. In particular, it pertains to structures and methods for improving adhesion and preventing micro cracks in low dielectric constant materials when used in conjunction with conventional dielectric materials as inter-metal dielectrics (IMD).

Integrated circuits and the progress made in Silicon Technology have continued to shrink the size of devices. This has led to closer and closer spacing of interconnection lines. As spacing becomes closer, the capacitance between adjacent lines has increased, as device geometries shrink and circuit densities increase. The capacitance between lines is directly related to both the distance between the lines and dielectric constant of the material in between the lines. Hence, a low dielectric material between the closely spaced interconnect lines is beneficial in reducing the capacitance.

In 0.25 micron, or below technology, e.g., 0.18, 0.13 um, the performance is limited by the interconnect line delay, with line-to-line capacitance being greatly affected by RC delay of the lines, as line width and line space becomes less than about

0.3 microns. Therefore, the introduction of low dielectric materials between the closely spaced interconnect, transmission lines can greatly enhance the integrated circuit performance in terms of speed, by lowering the RC time constants.

The low dielectric constant material in between and around the interconnect metal lines reduces the parasitic capacitance of the metal lines and hence increases signal speed and performance by lowering the RC time constant of the lines.

The Applicants have discovered that several problems arose using "conventional" methods, as shown in Applicant's prior art Fig. 1. One main problem discovered by the Applicants is the adhesion of the cap oxide #8 to the underlying layer of low dielectric constant material #6. Other discoveries by the Applicants were problems with the introduction of reaction gases that include oxygen and nitrous oxide gases prior to a cap oxide deposition. These gases are necessary for reaction chamber stabilization and were found to react with the surface of the low dielectric constant layer, making adhesion of the subsequent cap oxide worse. The present invention solves these problems, as described in Applicant's claims 23 - 27, and outlined in Applicant's Figure 2a-d.

CLAIMS REJECTIONS - 35 USC 103:

Reconsideration of the rejection of Claims 23, 25 and 27 under 35 U.S.C. 103(a), as being unpatentable over Jeng et al. (U.S. Patent No. 6,114,186) in view of Lucas et al. (U. S. Patent No. 6,287,951), is requested, based on the following.

There are patentable differences between the Prior Art cited and the Applicant's invention, namely the following.

The Applicant's curing conditions are not, as taught by Jeng:

" 300 ^{o}C by a hot plate bake ... ". Jeng (col. 4, lines 39-42);

Applicant's amended Claim 23, states low dielectric material curing at 400 ^{o}C.

Also, the Applicant states in amended Claim 23, that silicon nitride is both an adhesion promoter and stabilizing material, not taught by Jeng.

The Applicant's stabilizing material is not, as taught by Jeng:

"by plasmas with a thickness of about 1,000-3,000A" Jeng (col. 4, lines 42-60)

Jeng teaches layer #20, "cap layer", or inter-dielectric layer to be comprised of silicon dioxide. This is a key patentable difference from that of the Applicant's disclosure.

The Applicant's invention teaches the following stabilizing material:

The Applicant's dependent Claim 25 discloses that the method of independent Claim 23, for the layer of adhesion promoter and stabilizer is: a non-oxide compound.

"26. The method of claim 25, wherein said layer of adhesion promoter and stabilizer is silicon nitride, deposited by plasma enhanced chemical vapor deposition to a thickness of between about 200 and 500 Angstroms."

As stated above, the Applicant's invention teaches PE CVD, as the specific deposition method for the adhesion/stabilizer SiN layer, and the thickness range differs from the prior art. Therefore, the prior art neither teaches nor suggests the Applicant's method.

The Applicant's cap silicon oxide is not:
"cap silicon oxide layer (22) by PECVD with a thickness about 16,000 A".

The Applicant's invention teaches a cap silicon oxide:
Claim 27 depends on independent Claim 23, and states
",wherein said silicon oxide cap layer is deposited by plasma enhanced chemical vapor deposition, to a thickness of between about 4,000 to 16,000 Angstroms."

In sharp contrast, Jeng et al. teaches, in Col. 4 line 61, "The cap layer 20 may be followed by a thick, about 16,000 A, SiO_2, interlayer dielectric 22...".

Furthermore, Jeng's teachings have significant differences from that of the Applicant, ref. Jeng, Col. 4 lines 54 and 55, "The thickness of the cap layer is preferably about 1,000 to 3,000 A, and most preferably about 2,000 A."

Lucas et al. (U. S. Patent No. 6,287,951), primarily teaches forming a hardmask and an antireflective layer with silicon nitride, with a totally different application than that taught by the Applicant's claimed invention. The placement in the process for the "Lucas' nitride", is not to be used as a "stabilizer and

adhesion promoter" on low dielectric material, as is taught by the Applicant's invention; thus, demonstrating patentable differences. The Lucas disclosure neither teaches nor suggests, the Applicant's claimed invention.

Reconsideration of the rejection of Claim 24 under 35 U.S.C. 103(a), as being unpatentable over Jeng et al. (U.S. Patent No. 6,114,186) in view of Lucas et al. (U. S. Patent No. 6,287,951), as applied to claims 23, 25, 27, further in view of You et al (U.S Patent No. 6,197,703) is requested, based on the following.

The Applicant's curing conditions are not, as taught by Jeng:

" 300 ^{o}C by a hot plate bake ... ". Jeng (col. 4, lines 39-42).

Jeng in view of Lucas does not teach the following low dielectric curing conditions, as found in the Applicant's Claim 24.

In contrast, the Applicant's invention teaches the following curing conditions:

Claim 24 depends on independent Claim 23, and states, "wherein said low dielectric constant material is spun on

dielectric, deposited to a thickness of about 4,000 to 12,000 Angstroms, with curing conditions at 400°C for 1 hr., in a nitrogen ambient gas flow from about 1 to 30 SLM, oxygen less than 10 ppm."

Jeng et al. '186 in view of Lucas above, do not specifically show the curing conditions above, as taught by the Applicant's claimed invention.

Furthermore, both Jeng et al. '186 and You et al (U.S Patent No. 6,197,703), neither teach, nor suggest the Applicant's claimed invention. The above prior art are primarily concerned with processing HSQ material. There exist patentable differences from the Applicant's teaching in the above Claim 24, "low dielectric constant material is spun on dielectric." The Applicant's Claims do not mention, nor teach an HSQ process, nor an HSQ method. The reference "You", does teach and disclose in detail, equipment and process details relating to HSQ insulating layers; but, the Applicant's claimed invention does not teach, nor claim to have invented: the disclosed HSQ material, equipment, or processing. Furthermore, You does not teach, or suggest, in figures 1-2, col.5, lines 10-60 the Applicant's key combination of low dielectric layer combined with an adhesion/stabilizer SiN layer.

Finally, commenting on the "You" reference again, Figs. 1-2, layer 26 is SiN CAP that is sandwiched in between two layers of HSQ; but, the Applicant's figures contain patentable differences from that of "You". The "You" reference teaches SiN in between multi-level wiring layers, consisting of single layers of insulator. The Applicant's claimed invention teaches SiN in between a bi-level layer of low "k", dielectric layers, with the purpose of stabilizing and aiding adhesion between the bi-level layers of insulator, in the same wiring level, which is not the same as in the "You" Figs. 1 and 2.

Reconsideration of the rejection of Claim 26 under 35 U.S.C. 103(a), as being unpatentable over Jeng et al. (U.S. Patent No. 6,114,186) in view of Lucas et al. (U. S. Patent No. 6,287,951), as applied to claims 23, 25, 27, further in view of Jeng et al (U.S Patent No. 5,818,111) is requested, based on the following.

Jeng ('186, '111) in view of Lucas, does not disclose the thickness of the SiN layer between 200-500 Angtroms, Applicant's Claim 26. Jeng ('186, '111) teaches the stabilizing layer #20 to be silicon dioxide, which is preferred for low-k silicate dielectrics. Jeng does teach that a SiN layer can be used as a stabilizing layer in certain applications; but, fails to teach

that the silicon nitride layer can also be used as an adhesion promoter as well.

The Applicant teaches (Claim 25) that the layer of adhesion promoter and stabilizer is: a non-oxide compound. Furthermore, Applicant's Claim 26, dependent on Claim 25, "wherein said layer of adhesion promoter and stabilizer is silicon nitride, deposited by plasma enhanced chemical vapor deposition to a thickness of between about 200 and 500 Angstroms."

As stated above, the Applicant's invention teaches a non-oxide compound, deposited by PE CVD, as the specific deposition method for the adhesion/stabilizer SiN layer, with a thickness range that differs from the prior art. Therefore, the prior art neither teaches nor suggests the Applicant's method.

A question of obviousness of the Applicant's claimed invention has been raised in connection with the prior art presented, and it is related to the use of nitride as a protection layer over HSQ. The material HSQ is never mentioned either in the Applicant's Specifications, or in the Applicant's Claims. Most of the Prior Art cited by the Examiner is concerned with processing HSQ material. These are patentable differences

between what is taught by the prior art and what is taught by Applicant's Claims 23, 25 - 27.

As stated earlier, the Applicants have discovered that several problems arose using "conventional" methods, as shown in Applicant's prior art Fig. 1. One main problem discovered by the Applicants is the adhesion of the cap oxide #8 to the underlying layer of low dielectric constant material #6. Other discoveries by the Applicants were problems with the introduction of reaction gases that include oxygen and nitrous oxide gases prior to a cap oxide deposition. These gases are necessary for reaction chamber stabilization and were found to react with the surface of the low dielectric constant layer, making adhesion of the subsequent cap oxide worse. The present invention solves these problems, as described in Applicant's claims 23 - 27, and outlined in Applicant's Figure 2a-d.

The above drawbacks were difficult to detect, but easy to solve using the Applicant's claimed invention method. Non-obviousness is established below, because the Applicant's discovered the following process problems, that were difficult to detect but easy solved and addressed by the Applicant's claimed invention.

In conclusion, the Applicant's invention is believed to be patentable over prior art references of Jeng, Lucas, and You because there seems to insufficient basis for concluding that the modification of prior art disclosures to obtain the Applicant's invention, would have been obvious to one skilled in the art. That is to say, there must be something in the prior art or line of reasoning to suggest that the combination of several of these various references is desirable. We believe that there is no such basis for the combination.

The Examiner demonstrates a type of impermissible hindsight, by recognizing the advisability to combine the prior art references only after the Applicants have claimed the combination, as the motivation to combine the references.

Furthermore, at the time of the Claimed Invention, the Applicant's claimed invention was not "obvious to try", and the Applicant's claimed invention produces a synergistic result, that is greater than the sum of the parts, not found in Jeng, Lucas, and You.

The Applicants disagree with the Examiner, in that, we do not find present in the prior art, a good reason, suggestion or

motivation for combining the teachings of Jeng, Lucas, and You to produce the Applicant's claimed invention.

In fact, the prior art references actually "teach away" from the Applicant's Claimed Invention, as demonstrated below:
Jeng ('186, '111) in view of Lucas, does not disclose the thickness of the SiN layer between 200-500 Angtroms, Applicant's Claim 26. Jeng ('186, '111) teaches the stabilizing layer #20 to be silicon dioxide, which is preferred for low-k silicate dielectrics. Jeng does teach that a SiN layer can be used as a stabilizing layer in certain applications; but, fails to teach that the silicon nitride layer can also be used as an adhesion promoter as well. Jeng's cap layer thickness is different than the Applicant's. Lucas does not teach the SiN layer as a stabilizing layer. You teaches curing a HSQ layer, that is different than the Applicant's. Furthermore, the Applicant's SiN adhesion/stabilizing layer, coinciding with a low dielectric layer is not sketched the same in any of Lucas' figures.

FINAL REMARK

The Examiner Thanh T. Nguyen is thanked again for carefully examining and reviewing the subject Patent Application. With entry of this response to the Office Action, all claims are now considered to be in condition for allowance.

All rejected claims 23 - 27 are now believed to be in allowable condition, and allowance is so requested.

It is requested that should there be any problems with this response to the Office Action, please call the undersigned Attorney at (845) 452-5863.

Respectfully submitted,

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